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OFFICE OF
ENVIRONMENTAL
ASSESSMENT

MEMORANDUM

SUBJECT: Calculation of Residual Risk Estimates and Risk-Based Cleanup Goals for the Wyckoff Superfund Site

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1.0 Introduction

Human health risks and preliminary remediation goals were calculated for Operable Unit 01 (Eagle Harbor) as part of the 1989 Remedial Investigation, and was subsequently updated in 1991 (CH2M Hill 1991). The preliminary remediation goals (PRGs) were included in the 1994 Record of Decision. Because cleanup goals have not been met on portions of the intertidal beaches, EPA is now planning additional cleanup actions, as described in the Proposed Plan (EPA 2016). To ensure the additional cleanup actions adequately protect human health, updated residual risk estimates were calculated using more recent contaminant concentrations, and risk-based remedial goals were updated to account for revised exposure and toxicity information since the 1991 risk assessment.

Non-cancer hazards were not calculated because cancer is a more sensitive endpoint for the contaminants of concern (COCs) at Wyckoff. By example, assuming default rediential exposure assumptions, EPA's regional regional Screening screening level (RSL) for benzo(a)pyrene is 0.1 mg/kg assuming a target cancer risk of 1 x 10^{-6}, and 18 mg/kg assuming a noncancer hazard of 1. The corresponding cancer and non-cancer RSLs for pentachlorophenol are 1 mg/kg and 250 mg/kg, respectively (EPA 2017). Thus, cleanup actions that achieve PRGs based on a target cancer risk of 1 x 10^{-6} will be protective for both cancer and non-cancer effects.

2.0 Calculation of Residual Risk Estimates and Preliminary Remediation Goals

This technical memorandum presents the calculated residual cancer risk estimates and associated risk-based PRGs in sediment and biota. Risk-based PRGs for cPAHs and pentachlorophenol were calculated assuming an excess lifetime cancer risk greater than 1 x 10^{-6}. EPA (1993) has identified the following PAHs as carcinogenic:

- benzo(a)anthracene
- benzo(a)pyrene
- benzo(b)fluoranthene
- benzo(k)fluoranthene
- chrysene

- dibenz(a,h)anthracene
- indeno(1,2,3-c,d)pyrene

2.1 Calculation of Exposure Point Concentrations

The exposure point concentration (EPC) is defined as the average concentration contacted at the exposure point(s) over the duration of the exposure period (EPA, 1992). EPA recommends using the average concentration to represent “a reasonable estimate of the concentration likely to be contacted over time” (EPA 1989). Use of the average concentration also coincides with EPA toxicity criteria, which are based on lifetime average exposures. Because of the uncertainty associated with estimating the true average concentration at a site, EPA guidance (EPA 1989, 1992) notes that the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used for this variable. The UCL is defined as a value that, when calculated repeatedly for randomly drawn subsets of data, equals or exceeds the true population mean 95 percent of the time. Use of the UCL can also help account for uncertainties that can result from limited sampling data, and more accurately accounts for the uneven spatial distribution of contaminant concentrations. Exposure concentrations represent either the 95 percent UCL, or the maximum detected value when either there was insufficient data to calculate a UCL or the calculated UCL was greater than the maximum reported value. The 95 percent UCLs were calculated for each dataset following EPA guidance (EPA 2002a and EPA 2015). ProUCL version 5.1 (EPA 2015) was used to calculate the 95 percent UCLs.

Exposure concentrations in sediment were calculated using data collected for the YR17 Monitoring Report (USACE 2012). Exposure concentrations in clam tissue were calculated using data collected in 2011 (USACE 2012) and 2014 (USACE 2015). Only N1 samples were used in the analysis; field duplicate results were excluded. For those analytes not detected, the maximum reported detection limit was used as the exposure concentration. Where there were insufficient detections to calculate a defensible 95 percent UCL on the mean, the maximum reported concentration was used as the exposure concentration.

2.2 Calculation of Residual Risk Estimates

Two potentially exposed populations were evaluated based on consideration of current and potential future site uses; people engaged in recreational clamming and consumption, and Suquamish tribal members engaged in traditional tribal practices that include shellfish harvesting. Exposure pathways evaluated as complete were incidental ingestion and dermal contact with sediment during clamming activities, and consumption of clams harvested from the site.

Residual risk estimates were calculated assuming incidental ingestion and dermal contact with sediment during clamming activities. Dermal exposure to sediment was evaluated using two exposure assumptions: one, assuming that those engaged in clamming activities wore boots, and two, assuming that those engaged in clamming activities were barefoot, allowing for dermal exposure to the lower legs and feet. An exposure frequency of 151 days per year assumed for recreational and tribal direct contact with sediment while clamming and engaged in other recreational activities. Beaches at the Wyckoff site are exposed only when the tide is at or below 0.0 ft Mean Lower Low Water, which in a typical year occurs 155 days. Analysis of the tidal cycle from 2015 shows that the dyration of the low tide was 20 minutes or less for four days, which was considered insufficient time for any meaningful access to the beach.

2.2.1 Incidental Ingestion of Sediment

The following equation was used to estimate cancer risks associated with incidental ingestion of sediment:

$$Risk = \frac{C_{sed} \times IRS \times 10^{-9}\, kg/\mu g \times EF \times ED \times CSF}{BW \times AT}$$

Where:

C_{sed}	=	concentration in sediment (µg/kg)
IRS	=	sediment ingestion rate (mg/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	adult body weight (kg)
AT	=	averaging time (days)
CSF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$

2.2.2 Dermal Contact with Sediment

The following equation was used to estimate cancer risks from dermal contact with sediment:

$$Risk = \frac{C_S \times EF \times ED \times ABS \times DF_{adj} \times 10^{-9}\ kg/\ \mu g \times CSF}{BW_a \times AT}$$

Where:

C_{sed}	=	chemical concentration in soil or sediment (µg/kg)
ABS	=	absorption efficiency (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	adult body weight (kg)
AT	=	averaging time (days)
CSF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$
DF_{adj}	=	adjusted dermal exposure factor (mg/day)

Two separate analysis were conducted for dermal exposures, one assuming that individuals are wearing boots while harvesting clams, and one assuming harvesting while not wearing boots. When boots are worn, dermal exposure is assumed for the arms and hands. If boots are not worn, feet and legs are also assumed to be exposed. Adherence of sediment to exposed skin was weighted based on the exposed surface area and the part of the body that was exposed, and adjusted dermal factors were calculated as follows:

$$DF_{boots} = (SA_{arms} \times AF_{arms}) + (SA_{hands} \times AF_{hands})$$

$$DF_{no\text{-}boots} = (SA_{arms} \times AF_{arms}) + (SA_{hands} \times AF_{hands}) + (SA_{legs} \times AF_{legs}) + (SA_{feet} \times AF_{feet})$$

Where:

SA = exposed skin surface area (cm^2)
AF = sediment-to-skin adherence factor (mg/cm^2)

2.2.3 Consumption of Shellfish

While the risks associated with harvesting shellfish were calculated assuming harvesting is done by adults, risks associated with consumption of shellfish were calculated assuming the harvest is shared with the entire family. Thus, exposure is assumed to occur during childhood and continue into adult years. Shellfish consumption rates for children aged 6 years and younger were calculated by assuming that their intake is approximately 42 percent of an adult, based on the ratio of child-to-adult consumption rates presented in the CRITFC Fish Consumption Survey (CRITFC 1994).

Benzo(a)pyrene is known to cause cancer via a mutagenic mode of action (EPA 2005). Consistent with EPA's revised Cancer Assessment Guidelines, the following default Age Dependent Adjustment Factors (ADAFs) are used to account for the increased cancer risk when exposure occurs early in life:

- 10-fold adjustment for exposures during the first 2 years of life;
- 3-fold adjustment for exposures from ages 2 to <16 years of age; and
- No adjustment for exposures after turning 16 years of age.

The following equation was used to calculate cancer risks associated with consumption of cPAHs shellfish:

$$Risk = \frac{C_{shellfish} \times CR_{shellfish\text{-}adj} \times CSF \times 10^{-3}\, kg/g \times 10^{-3}\, g/mg}{AT}$$

Where:

$C_{shellfish}$ = chemical concentration in shellfish (µg/kg)
$CR_{shellfish\text{-}adj}$ = age-adjusted shellfish consumption rate for early-life exposures (g/day)
AT = averaging time (days)
CSF = cancer slope factor $(mg/kg\text{-}day)^{-1}$

Where

$$CR_{shellfish-adj} = \left(\frac{(EF_{0\text{-}2} \times ED_{0\text{-}2} \times CR_{shellfish} \times 0.42) \times 10}{BW_c} + \frac{(EF_{2\text{-}6} \times ED_{2\text{-}6} \times CR_{shellfish} \times 0.42) \times 3}{BW_c} + \frac{(EF_{6\text{-}16} \times ED_{6\text{-}16} \times CR_{shellfish}) \times 3}{BW_a} + \frac{(EF \times ED_{16\text{-}26} \times CR_{shellfish}) \times 1}{BW_a} \right)$$

And:

EF	=	exposure frequency (days/year)
$ED_{0\text{-}2}$	=	exposure duration ages 0-2 (years)
$ED_{2\text{-}6}$	=	exposure duration ages 2-6 (years)
$ED_{6\text{-}16}$	=	exposure duration ages 6-16 (years)
$ED_{16\text{-}26}$	=	exposure duration ages 16-26 (years)
BW_a	=	adult body weight (kg)
BW_c	=	child body weight (kg)

When assessing shellfish consumption risks for Suquamish tribal consumers, the overall exposure duration was adjusted to assume a lifetime exposure of 64 years, and the exposure duration after 16 years of age was adjusted to account for an exposure duration of 16 to 64 years of age (54 years).

2.3 Calculation of Risk-Based Cleanup Goals

Risk-based cleanup goals were calculated using the assumptions and methodologies described in Section 2.2, and solving the equations for concentrations in sediment and shellfish tissue, assuming a target risk level of 1 x 10^{-6}.

2.3.1 Incidental Ingestion of Sediment

The following equation is used to calculate risk-based PRGs associated with incidental ingestion of contaminants in sediment:

$$RBC_{\text{sed}} = \frac{TR \times BW \times AT_c}{EF \times ED \times CSF \times IRS \times 10^{-9}\, kg/\mu g}$$

Where:

IRS	=	incidental sediment ingestion rate (mg/day)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kg)
AT_c	=	averaging time, cancer (days)
TR	=	target cancer risk
CSF	=	cancer slope factor $(mg/kg\text{-}day)^{-1}$

2.3.2 Dermal Contact with Sediment

The following equation is used to calculate risk-based PRGs associated with dermal contact with contaminants in sediment:

$$RBC_{sed} = \frac{TR \times AT_c \times BW}{EF \times ED \times CSF \times DF_{adj} \times ABS \times 10^{-9}\ kg/\mu g}$$

Where:

ABS	=	dermal absorption efficiency
DF_{adj}	=	adjusted dermal exposure factor
EF	=	exposure frequency (days/year)
ED	=	exposure duration – adult (years)
BW	=	body weight (kg)
AT_c	=	averaging time (days)
CSF	=	cancer slope factor (mg/kg-day)-1
TR	=	target excess cancer risk

The individual RBCs associated with incidental ingestion and dermal contact with sediment were then combined using the following equation:

$$RBC_{sed} = \frac{1}{\frac{1}{RBC_{sed} - Ingestion} + \frac{1}{RBC_{sed} - dermal}}$$

2.3.3 Consumption of Shellfish

The following equation is used to calculate risk-based concentrations in shellfish:

$$RBC_{shellfish} = \frac{TR \times AT}{CR_{shellfish\text{-}adj} \times CSF \times 10^{-3} kg/g \times 10^{-3}\ mg/\mu g} \times$$

Where:

$RBC_{shellfish}$	=	chemical concentration in tissue (µg/kg)
$CR_{shellfish\_adj}$	=	age-adjusted shellfish consumption rate (g/day)
AT	=	averaging time (days)
TR	=	target risk

Calculation of RBCs for cPAHs in clam tissue used the age-adjusted shellfish consumption rate described in Section 2.2.3. When calculating the RBC in clams for contaminants other than cPAHs, the age-adjusted shellfish consumption rate was calculated using the following equation:

$$CR_{shellfish\text{-}adj} = \left(\frac{EF_c \times ED_c \times (CR_{shellfish} \times 0.42)}{BW_c}\right) + \left(\frac{EF_a \times (ED_a - ED_c) \times CR_{shellfish}}{BW_a}\right)$$

Where:

EF_c	=	exposure frequency – children (days/year)
ED_c	=	exposure duration – children (days/year)
BW_c	=	body weight – children (kg)
$CR_{shellfish}$	=	consumption rate – shellfish (g/kg)
EF_a	=	exposure frequency – adult (days/year)
ED_a	=	exposure duration – adult (days/year)
BW_a	=	body weight – adult (kg)

2.4 References

CH2M Hill. 1991. Revised Risk Assessment, Eagle Harbor Operable Unit, Wyckoff/Eagle Harbor Superfund Site. May.

Columbia River Inter-Tribal Fish Commission (CRITFC). 1994. A Fish Consumption Survey of the Umatilla, Nez Perce, Yakama, and Warm Springs Tribes of the Columbia River Basin, Technical Report 94-3. Columbia River Inter-Tribal Fish Commission, Portland, OR. October 1994.

EPA. 1989. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A), Interim Final. Office of Solid Waste and Emergency Response, EPA/540/1-89/002. December 1989.

EPA. 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term. OSWER Publication 9285.7-081.

EPA. 1993. Provisional Guidance for Quantitative Risk Assessment of Polycyclic Aromatic Hydrocarbons. Office of Health and Environmental Assessment, EPA/600/R-93/089. July 1993.

EPA. 2002a. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response. OSWER 9285.6-10. December 2002.

EPA. 2002b. Estimated Per Capita Fish Consumption in the United States. EPA 821-C-02-003. August 2002.

U.S. Environmental Protection Agency (EPA) 2004. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part E, Supplemental

Guidance for Dermal Risk Assessment), Final. Office of Emergency and Remedial Response. EPA/540/R/99/005. July 2004.

EPA. 2005. Supplemental Guidance for Assessing Susceptibility from Early-Life Exposure to Carcinogens. Risk Assessment Forum. Washington, D.C. EPA/630/R-03/003F. March 2005.

EPA Region 10 (EPA). 2007. Framework for Selecting and Using Tribal Fish and Shellfish Consumption Rates for Risk-Based Decision Making at CERCLA and RCRA Cleanup Sites in Puget Sound and the Strait of Georgia. August.

EPA. 2011. Exposure Factors Handbook: 2011 Edition. National Center for Environmental Assessment, Office of Research and Development, EPA/600/R-09/052F.

EPA 2014. Human Health Exposure Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER Directive 9200.1-120. February 6, 2014.

EPA. 2015. ProUCL Version 5.1 Technical Guide. EPA/600/R-07/041. October 2015.

EPA. 2016. Proposed Plan for Amending the Records of Decision for the Wyckoff/Eagle Harbor Superfund Site (Operable Units 1, 2, and 4). April.

EPA, 2017.Regional Screening Levels, Office of Superfund Remediation and Technology Innovation. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-november-2017

IRIS, 2010. Toxicological Review of Pentachlorophenol. Integrated Risk Information System, National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency. EPA/635/R-09/004F. September.

IRIS, 2017. Toxicological Review of Benzo(a)pyrene. Integrated Risk Information System, National Center for Environmental Assessment, Office of Research and Development, U.S. Environmental Protection Agency. EPA/635/R-17/003Fa. January.

Suquamish, 2000. Fish Consumption Survey Of The Suquamish Indian Tribe Of The Port Madison Indian Reservation, Puget Sound Region. August 2000

U.S. Army Corps of Engineers (USACE). 2012. Final 2011 Year 17 Monitoring Report, East Harbor Operable Unit, Wyckoff/Eagle Harbor Superfund Site. Prepared by HDR Engineering Inc., Science and Engineering for the Environment, LLC, and Ken Taylor Associates, Inc. September 7.

U.S. Army Corps of Engineers (USACE). 2015. Clam Tissue Collection Report, Wyckoff/Eagle Harbor Superfund Site. October 23.

Table 1: Exposure Factors				
Description		**Units**	**Value**	**Reference**
Incidental sediment ingestion rate – Tribal exposures	SIR_{tribal_beach}	mg/day	100	EPA 2014
Incidental sediment ingestion rate – recreational exposure	SIR_{rec_beach}	mg/day	100	EPA 2014
Shellfish consumption rate - clams	$CR_{shellfish}$	g/day	18	EPA 2002
Shellfish consumption rate - Tribal	$CR_{Suquamish}$	g/day	498.4	EPA 2007
Exposure frequency – shellfish consumption - Tribal	EF	days/yr	365	
Exposure frequency – shellfish consumption - recreational	EF	days/yr	350	EPA 2014
Sediment exposure frequency – clamming - Tribal	EF_{rec_adult}	days/yr	151	
Sediment exposure frequency – clamming - recreational	EF_{rec_adult}	days/yr	151	
Exposure duration - recreational	ED	yrs	26	EPA 2014
Exposure duration - Tribal	ED_{tribal}	yrs	64	
Body weight - Tribal	BW	kg	79	Suquamish, 2000
Body weight - adult	BW_a	kg	80	EPA 2014
Body weight - child 0-2 yrs	BW_{0-2}	kg	8.6	EPA 2011
Body weight - child 2-6 yrs	BW_{2-6}	kg	16.2	EPA 2011
Body weight - child 6-16 yrs	BW_{6-16}	kg	44.3	EPA 2011
Exposed Skin Surface Area - Clamming - arms	SA_{arms}	cm^2	3,325	EPA 2011
Exposed Skin Surface Area - Clamming - hands	SA_{hands}	cm^2	1,185	EPA 2011
Exposed Skin Surface Area - Clamming - legs	SA_{legs}	cm^2	8,055	EPA 2011
Exposed Skin Surface Area - Clamming - feet	SA_{feet}	cm^2	1,535	EPA 2011
Adherence Factor - arms	AF_{arms}	mg/cm^2	0.12	EPA 2011
Adherence Factor - hands	AF_{hands}	mg/cm^2	0.88	EPA 2011
Adherence Factor - legs	AF_{legs}	mg/cm^2	0.16	EPA 2011
Adherence Factor - feet	AF_{feet}	mg/cm^2	0.58	EPA 2011
Averaging time - cancer	AT_c	days	25,550	EPA 2014
Target Risk	TR		1E-06	

Table 2: Chemical-Specific Criteria				
	CSF $(mg/kg\text{-}day)^{-1}$	**Reference**	**ABS**	**Reference**
Benzo(a)pyrene	1.0	IRIS 2016	0.13	EPA 2004
Benzo(a)anthracene	0.1	EPA 1993	0.13	EPA 2004
Benzo(b)fluoranthene	0.1	EPA 1993	0.13	EPA 2004
Benzo(k)fluoranthene	0.01	EPA 1993	0.13	EPA 2004
Chrysene	0.001	EPA 1993	0.13	EPA 2004
Dibenz(a,h)anthracene	1	EPA 1993	0.13	EPA 2004
Indeno(1,2,3-c,d)pyrene	0.1	EPA 1993	0.13	EPA 2004
Pentachlorophenol	0.4	IRIS 2010	0.25	EPA 2004

Table 3: Cancer Risk for Recreational Beach Users											
		Exposure Concentration			Dermal Exposure			Total - (Direct Contact)		Total (all pathways)	
COC	CSF $(mg/kg\text{-}day)^{-1}$	Sediment Exposure Concentration (µg/kg)	Shellfish Exposure Concentration (µg/kg)	Incidental Ingestion	Beach use (with boots)	Beach use (no boots)	Consumption of Shellfish	Boots	No Boots	Boots	No Boots
Benzo(a)pyrene	1.0E+00	688	1.7	5.E-08	1.E-07	2.E-07	9E-07	2E-07	3E-07	1E-06	1E-06
Benzo(a)anthracene	1.0E-01	2361	5.5	2.E-08	3.E-08	8.E-08	3E-07	5E-08	1E-07	3E-07	4E-07
Benzo(b)fluoranthene	1.0E-01	814	5.5	6.E-09	1.E-08	3.E-08	3E-07	2E-08	4E-08	3E-07	3E-07
Benzo(k)fluoranthene	1.0E-02	814	1.3	6.E-10	1.E-09	3.E-09	7E-09	2E-09	4E-09	8E-09	1E-08
Chysene	1.0E-03	2297	12.5	2.E-10	3.E-10	8.E-10	6E-09	5E-10	1E-09	7E-09	7E-09
Dibenz(a,h)anthracene	1.0E+00	80	0.9	6.E-09	1.E-08	3.E-08	5E-07	2E-08	4E-08	5E-07	5E-07
Indeno(1,2,3-c,d)pyrene	1.0E-01	121	1.9	9.E-10	2.E-09	4.E-09	1E-07	3E-09	5E-09	1E-07	1E-07
							Total	**2E-07**	**5E-07**	**2E-06**	**2E-06**

Table 4: Cancer Risk for Tribal Shellfish Harvesters (Suquamish values)											
					Dermal Exposure			Total - (Direct Contact)		Total (all pathways)	
COC	CSF $(mg/kg\text{-}day)^{-1}$	Sediment Exposure Concentration (µg/kg)	Shellfish Exposure Concentration (µg/kg)	Incidental Ingestion	Shellfish harvester (with boots)	Shellfish harvester (barefoot)	Consumption of Shellfish	Boots	No Boots	Boots	No Boots
Benzo(a)pyrene	1.0E+00	688	1.7	8.E-07	8.E-07	1.E-06	4.E-06	3E-05	2E-06	4E-06	3E-05
Benzo(a)anthracene	1.0E-01	2361	5.5	3.E-07	3.E-07	5.E-07	1.E-06	1E-05	8E-07	2E-06	1E-05
Benzo(b)fluoranthene	1.0E-01	814	5.5	9.E-08	9.E-08	2.E-07	4.E-07	1E-05	3E-07	5E-07	1E-05
Benzo(k)fluoranthene	1.0E-02	814	1.3	9.E-09	9.E-09	2.E-08	4.E-08	3E-07	3E-08	5E-08	3E-07
Chysene	1.0E-03	2297	12.5	3.E-09	3.E-09	5.E-09	1.E-08	2E-07	7E-09	1E-08	2E-07
Dibenz(a,h)anthracene	1.0E+00	80	0.9	9.E-08	9.E-08	2.E-07	4.E-07	2E-05	3E-07	5E-07	2E-05
Indeno(1,2,3-c,d)pyrene	1.0E-01	121	1.9	1.E-08	1.E-08	3.E-08	6.E-08	4E-06	4E-08	8E-08	4E-06
								Total	**4E-06**	**7E-06**	**8E-05**

Table 5: Risk-Based Cleanup Goals for Recreational Exposures			
COC	Sediment (with boots) (µg/kg)	Sediment (barefoot) (µg/kg)	Shellfish tissue (µg/kg)
Benzo(a)pyrene	4,558	2,296	1.9
Benzo(a)anthracene	45,585	22,958	19
Benzo(b)fluoranthene	45,585	22,958	19
Benzo(k)fluoranthene	455,846	229,581	194
Chysene	4,558,460	2,295,808	1945
Dibenz(a,h)anthracene	4,558	2,296	1.9
Indeno(1,2,3-c,d)pyrene	45,585	22,958	19
Pentachlorophenol	7,114	3,259	24

Table 6: Risk-Based Cleanup Goals for Tribal Exposures			
COC	Sediment (with boots) (µg/kg)	Sediment (without boots) (µg/kg)	Shellfish tissue (µg/kg)
Benzo(a)pyrene	308	155	0.05
Benzo(a)anthracene	3,080	1,551	0.5
Benzo(b)fluoranthene	3,080	1,551	0.5
Benzo(k)fluoranthene	30,798	15,511	5.3
Chysene	307,982	155,111	53
Dibenz(a,h)anthracene	308	155	0.05
Indeno(1,2,3-c,d)pyrene	3,080	1,551	0.5
Pentachlorophenol	481	220	0.2

Attachment 1

Wyckoff East Beach and Intertidal Sediment Sample Results

	Analyte													
	Benzo(a)anthracene		Chrysene		Benzo(b)fluoranthene		Benzo(k)fluoranthene		Benzo(a)pyrene		Indeno(1,2,3-cd)pyrene		Dibenz(a,h)anthracene	
Sample Number	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier
F12-D1	4.7	U	3.3	J	2.1	J	2.1	J	4.7	U	4.7	U	4.7	U
G12-B2	4.7	U	2.8	J	4.7	U	4.7	U	4.7	U	4.7	U	4.7	U
H12-A2	4.8	U	4.8	U	1.2	J	1.2	J	4.8	U	4.8	U	4.8	U
G11-A4	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U
I12-C2	4.9	U	3.4	J	2.2	J	2.2	J	4.9	U	4.9	U	4.9	U
J11-A5	4.2	J	13		8.4		8.4		4.7		3.3	J	4.7	U
J11-D2	9.6		11		6.4		6.4		4.1	J	3.7	J	4.6	U
J10-E5	18		27		20		20		18		8.7		5.1	
K9-B4	270		460		340		340		210	J	67		35	
M9-A3	13		17		17		17		14		6.8	J	8.5	U
L9-D4	37		44		32		32		28		13		5.5	
L9-B4	69		79		60		60		47		22		8.7	
K9-D3	700		1,000		480		480		430		170		84	
N10-B4	25		30		22		22		19		9.2		3.7	J
N11-A5	39		45		36		36		39		22		14	J
N11-B5	6.2		5.7		6.7		6.7		5.3		3.4	J	4.8	UJ
N11-B4	5.4		7.3		7.3		7.3		3.9	J	4.9	U	4.9	UJ
N11-B3	49		59		24		24		26		8.4		5.1	J
N11-B2	34		54		35		35		28		18		9.8	J
N11-A2	7.9		9.9		7.0		7.0		6.0		5.0	U	5.0	UJ
N11-A1	25		43		28		28		20		12		7.3	J
N10-A5	19		35		19		19		16		10		3.8	J
N10-A4	150		240		74		74		55		21		14	J
M10-E4	360		660		140		140		94		37		24	J
N11-C5	3.7	J	8.0		6.6		6.6		2.8	J	4.7	U	4.7	UJ

	Analyte													
	Benzo(a)anthracene		Chrysene		Benzo(b)fluoranthene		Benzo(k)fluoranthene		Benzo(a)pyrene		Indeno(1,2,3-cd)pyrene		Dibenz(a,h)anthracene	
Sample Number	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier
N11-D5	3.8	J	5.3		7.0		7.0		4.3	J	4.8	U	4.8	UJ
N11-C4	6.1		8.0		7.6		7.6		5.2		4.7	U	4.7	UJ
N11-C2	52		75		68		68		34		15		5.6	J
N10-B5	34		43		28		28		21		7.4		4.2	J
M10-E4	320		460		380		380		370		95		60	
N10-A4	7,100		5,900		2,300		2,300		1,900		450		320	
N10-B4	170		170		130		130		110		27		16	
N11-A2	2,700		4,200		940		940		880		200		120	
N11-B2	16		19		29		29		24		6.4		4.6	
N11-B5	460		390		180		180		160		42		23	
N11-C5	12		11		13		13		13		4.6		2.3	J
N11-D5	81		79		66		66		47		12		6.8	

Attachment 2

Wyckoff Clam Tissue Data

Sample Location	East Beach #4		East Beach #5		East Beach #6		North Shoal #4		North Shoal #5		North Shoal #6		Intertidal Beach #4		Intertidal Beach #5		Intertidal Beach #6	
Compound	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier	Result µg/kg	Qualifier
Benz(a)anthracene	2.10		3.00		2.90		2.80		3.50		2.60		2.40		2.20		3.40	
Benzo(a)pyrene	1.20		1.60		1.90		3.40		3.00		2.30		1.30		1.10		1.50	
Benzo[b]fluoranthene	0.93	U	1.7		1.9		4.2		3.3		2.9		2.2		1.8		2.6	
Benzo[k]fluoranthene	0.93	U	0.93	U	0.95	U	1.20		1.10		1.40		0.92	U	0.93	U	0.95	U
Chrysene	1.9	U	1.9	U	1.9	U	1.9	U	1.8	U	1.9	U	1.8	U	1.9	U	1.9	U
Dibenz[a,h]anthracene	0.93	U	0.93	U	0.95	U	0.95	U	0.91	U	0.94	U	0.92	U	0.93	U	0.95	U
Indeno(1,2,3-cd)pyrene	1.90	U	1.90	U	1.90	U	1.90	U	1.80	U	1.90	U	1.80	U	1.90	U	1.90	U